EVOLUTION OF THE HGP-A POWER PLANT

John W. Shupe*

In the late 1960's, the realization began to emerge in Hawaii that there were a number of indigenous renewable energy resources that could lessen the vulnerability of the State to dislocations that occur in the global oil market, including a variety of solar technologies, biomass, ocean thermal, and geothermal energy. An early consensus surfaced that the energy option which seemed to hold the greatest potential for commercialization was geothermal base load power.

Consequently, the Hawaii Geothermal Project (HGP) was organized by the University of Hawaii to focus on the identification and utilization of geothermal energy resources in Hawaii. The Big Island of Hawaii, as both the largest and youngest in the island chain and still growing from recent activity of the Mauna Loa and Kilauea volcanoes, is the island with the greatest amount of heat at or near the earth's surface. Therefore, the Big Island was selected as the appropriate site for initial geothermal exploration, with subsequent surveys to proceed throughout the island chain.

The HGP came into being when the 1972 Hawaii State Legislature allocated $200,000 for geothermal research, contingent on the University obtaining matching federal funds. This was well before the Middle East oil embargo and resulting energy crisis; so was a progressive step for a state legislature to take. From the beginning, this project has been a joint effort of all segments of the public and private sectors. A budget summary of the total support of $13,377,000 that was expended during the eight years from exploratory surveys through construction of the power plant is listed in Table 1.

*Director, Pacific Site Office, U.S. Department of Energy

Table 1. Eight-Year Budget for HGP-A
(May 1973 through May 1981)

	Budget figures in $1000's			
	Federal Funding	State & County	Private Sector	Total Budget
Phase I:				
Exploratory Surveys	$ 588	$ 200	$ 39	$ 827
Phase II:				
Drilling & Initial Well Testing	1472	500	105	2077
Phase III:				
Well Testing and Analysis	417	66	--	483
Phase IV:				
Design & Installation of Generator	8314	1621	55	9990
TOTAL	$10,791	$2,387	$199	$13,377
PERCENT	80.7	17.8	1.5	100.0

Research got underway in the summer of 1973, with separate programs established for Geophysics, Engineering, Environmental-Socioeconomics, and Experimental Drilling, with Augustine Furumoto, Paul Yuen, Robert Kamins, and Agatin Abbott serving as directors for their respective programs. The major emphasis of Phase I was on geophysical surveys, but support activity was begun in the other programs as well. It became evident in early 1974 that an exploratory drilling program would be required to verify the sub-surface conditions predicted by the surveys. Initially it was the intent to proceed with multiple drilling of both deep and shallow wells, but fiscal restraints limited the exploratory drilling "program" to one deep well.

The Site Selection Committee for this well was chaired by the former Dr. Agatin T. Abbott, after whom the well was ultimately named -- HGP-A, for Abbott. The committee considered all geophysical, geological, and geochemical evidence and selected as the optimum site a location in the Puna District near the eastern rift of Kilauea Volcano. No State or County land suitable for drilling was available near the selected site, and permission was granted by Arthur and Richard Lyman to drill on property of the Kapoho Land and Development Company, approximately three miles southeast of Pahoa. Figure 1 shows the location of the drill site, along with the volcanoes and rift zones on the island of Hawaii. The elevation of this site is just under 600 feet above sea level.

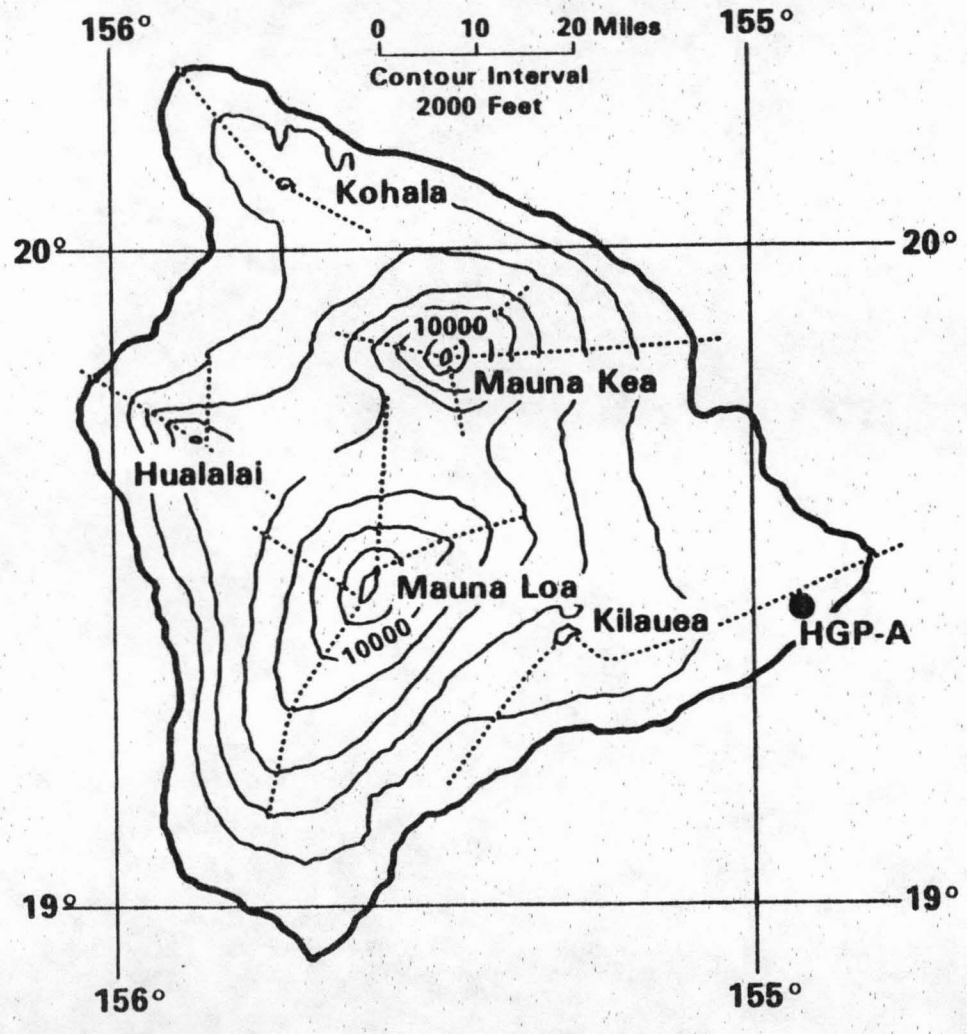
Specifications for drilling were drawn up and invitations to bid were sent in early June 1975 to 28 drilling companies on the mainland, in Canada, and throughout the Pacific area. The only bid submitted was by Water Resources International Inc. of Honolulu and, following extensive negotiations, the drilling subcontract was let in late-November 1975. A New Zealand geothermal consulting firm, KRTA, was commissioned to provide technical assistance and supervision of the drilling operation.

Drilling of this experimental well commenced on December 10, 1975, under the able direction of Gordon A. Macdonald, who took over the drilling program on Dr. Abbott's death. The well was completed to a depth of 6450 feet on April 27, 1976. Cores of the subsurface strata were taken at approximately 700-foot intervals and samples of cuttings were obtained every five to ten feet throughout drilling. Below 4000 feet the drilling mud began to heat up rapidly, and subsequent mud temperature measurements approached 600°F. This high temperature was sufficiently encouraging to justify installing a slotted liner, flushing out the mud, and conducting a well testing program.

Preliminary well testing proceeded through the summer of 1976. The well was first flashed to steam and permitted to flow briefly on July 2. The rate of discharge of steam was impressive but

FIGURE 1

Locations of HGP-A, Volcanoes and Rift Zones on the Island of Hawaii



noisy -- roughly equivalent to that of a 747 jet aircraft at take off. Steam was discharged continously for four hours on July 22, verifying that some natural flow into the wellbore was taking place. The quality of the fluid from HGP-A was generally good -- surprisingly low in chloride content, mercury, and hydrogen sulphide, but with significant amounts of silica.

Because of the extremely high noise level generated during discharge, a silencer-separator was constructed before proceeding with a more comprehensive testing program. A two-week flow test was performed from November 3 to 17 with wellhead temperature, pressure and other scientific measurements recorded throughout. Temperature and pressure profiles for the full 6450-foot well depth were obtained during a six-day flow test conducted in mid-December, followed by a determination of the pressure build-up after the well was shut in.

Since the steam quality was so high, the initial silencer was only partially successful, and objections to the noise level continued to be raised by families in the area. In late December and early January, additional muffling and stiffening were built into the silencer, after which a series of throttled flow tests was conducted to provide a better assessment of the well and to obtain preliminary design data for a wellhead generator. The results of these preliminary tests were sufficiently encouraging that a 90-day flow test was planned to begin in late March. However, the nuisance effect of both the noise and the hydrogen sulfide emissions, combined with the fact that the pressure-time curves for the well seemed to stabilize early, led to the termination of the test after six weeks on May 9.

Test results showed that HGP-A is one of the hottest geothermal wells in the world; the highest downhole temperature encountered was 676°F. Well testing indicated that there was sufficient natural two-phase flow into the wellbore for HGP-A to maintain a reasonable flow rate of high quality fluid for the 30-year life expectancy of a generating plant. The Kapoho

Geothermal Field associated with this first successful geothermal well in Hawaii should have a capacity of at least 500 MW of electrical energy for 100 years. Therefore, it exhibits great economic potential for the Island and for the State of Hawaii. The early installation of a wellhead generator, both to provide power for the Big Island electric grid and to obtain additional information on the nature and the extent of the geothermal resource, was the next logical step for developing the field.

To this end a consortium, the HGP-A Development Group (HGP-A/DG) was formed with the responsibility for constructing and operating an electrical generating plant using the steam from HGP-A. The consortium consisted of the State of Hawaii as the lead agency, the County of Hawaii, and the University of Hawaii through the Hawaii Geothermal Project. Because of legal limitations, neither the Hawaii Electric Light Company (HELCO) on the Big Island nor the parent organization, the Hawaiian Electric Company (HECO) of Honolulu, became full members of the HGP-A/DG; but both utilities have been active participants in the program.

Preliminary negotiations between the HGP-A/DG and the U.S. Department of Energy were completed on June 9, 1978, with the signing of a four-year $6,751,014 contract to install and operate a three-megawatt wellhead generator. Subsequent cost increases raised this figure to $9,990,000, as shown in Table 1, and an additional million dollar advance was provided by Hawaii Electric Light Company to cover shakedown costs and make the plant fully operational. The HGP-A geothermal power plant began generating electricity commercially for the HELCO grid in March 1982; and future presentations at this seminar will document the excellent performance to date of this plant during its first 2½ years of service.

In summary, the evolution of the HGP-A power plant was a classic case study of effective cooperation among all levels of Federal, State, and County governments, the University, and the private sector in the development of a high-risk technology.

Because of the uncertainty of the resource base and the possibility of volcanic activity at the rift zone drill site, as well as a limited market demand on the Big Island for geothermal power, it was difficult to identify private capital for exploratory drilling. Once the geothermal resource was confirmed, however, primarily with public funding, the private sector is now assuming its appropriate role in the commercialization of geothermal power as a major component in Hawaii's energy future.